HYDROLOGY

Precipitation

The average annual precipitation in Bolivar, MO, is 42.88 inches. An average of 97.5 days will have ≥0.01 inches of precipitation, 28.2 days will have ≥0.05 inches and 11.6 days will have ≥1.0 inches. The average annual snowfall is 12.2 inches.

Gaging Stations

There are three active gage stations in the Watershed maintained by the USGS (Table HY01; Figure HY01). Two other gage stations historically were located on the Pomme de Terre River, however, these were terminated in the mid-1960s (Table HY01). Mean monthly discharges at all currently active stations are the lowest in August and highest in March or April (Table HY02). Flow ceases regularly in Lindley Creek; once every 2 years the discharge at gage station 06921200 will be 0.0 cfs for 7 days (Table HY02; Figures HY02 and HY03) (MDNR 1997).

Dam and Hydropower Influences

There are 10 known large dams (>30 surface acres) located in the Watershed (Table HY03).

Pomme de Terre River has been significantly altered by the construction of PDT and Truman lakes. Both Pomme de Terre and Harry S. Truman dams were constructed as multipurpose projects designed to provide hydroelectric power and flood control. Although Pomme de Terre Dam was designed and authorized to generate electricity, it has not been used for this purpose. Pomme de Terre Lake is being used as part of the Osage River Basin flood protection for the and Truman Lake, and to provide recreational use.

The construction of the two dams has dramatically changed the physical and biological character of the Pomme de Terre River. Table HY04 shows the modifications to the original PDT River channel as a result of construction of the two reservoirs. The segment of river between Pomme de Terre Dam and the historic confluence with the Osage River (total of 41.6 river miles Truman Lake) no longer functions in the same manner as it did before impoundment. From discharge data provided in the USGS Water Resource Data reports for Missouri, it appears that the dam is operated in a manner consistent with a "run-of-the-river" facility with a storage pool (Yeager 1993). Even so, the hydrologic regime of this segment has been altered to the point that it no longer exhibits the naturally fluctuating flow of an unimpounded river (Yeager 1993).

The PDT Arm of Truman Lake at normal pool (706 feet mean sea level (msl)) impounds 20 miles of the preimpoundment PDT River channel. At normal pool elevation (839 ft. msl), Pomme de Terre Lake impounds 18.3 miles of the original Pomme de Terre River channel. This expands to 28.3 miles when the flood pool is at peak capacity (874 ft. msl). In summary, the construction of these two reservoirs inundates 59.6 river miles, or the downstream 46% of the original PDT River channel, when PDT Lake is at normal pool level. When PDT Lake is at flood pool, 69.6 river miles, 54%, of the original Pomme de Terre River channel is impounded.

Nutrient and sediment deprivation are believed to occur in the Pomme de Terre River below Pomme de

Figure HY01. Active USGS gaging stations in the Pomme de Terre River watershed.

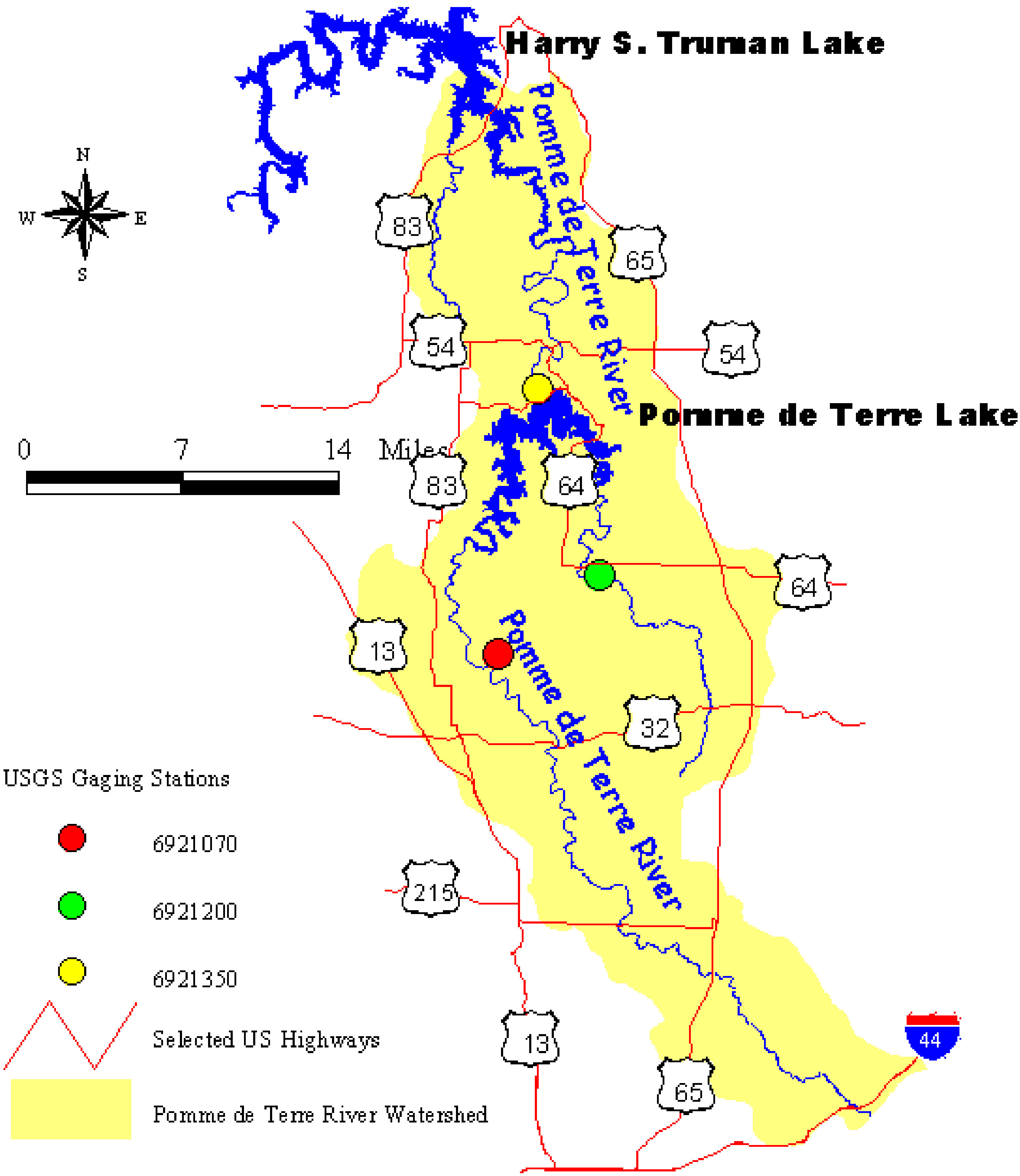
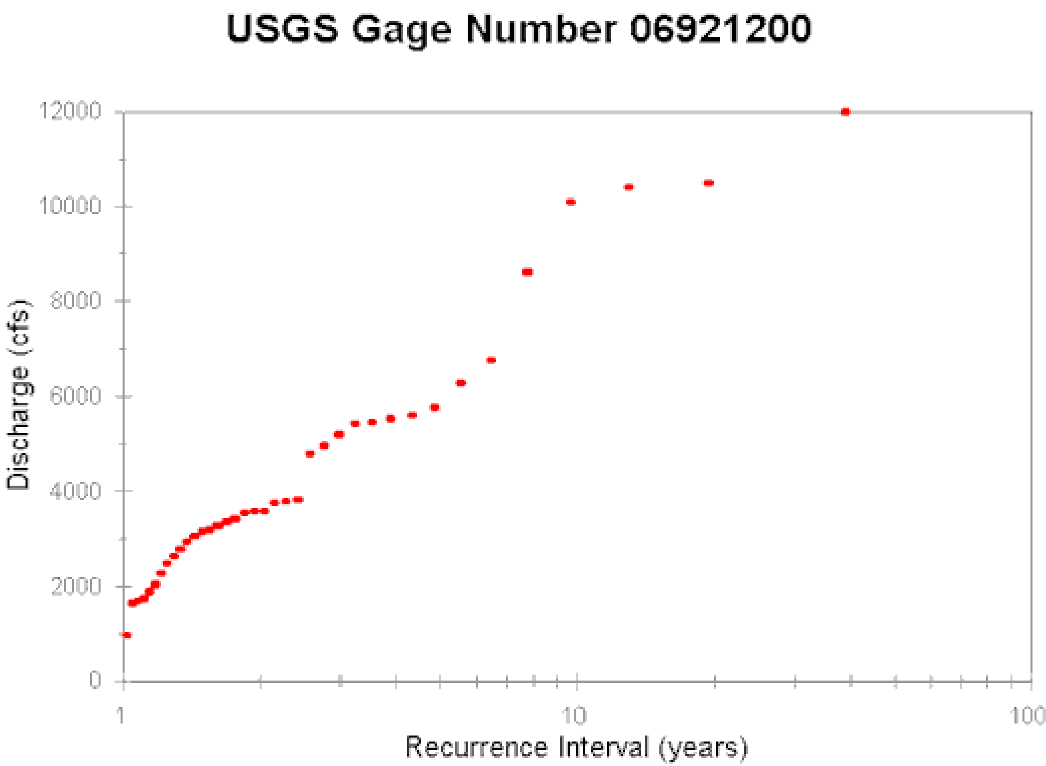
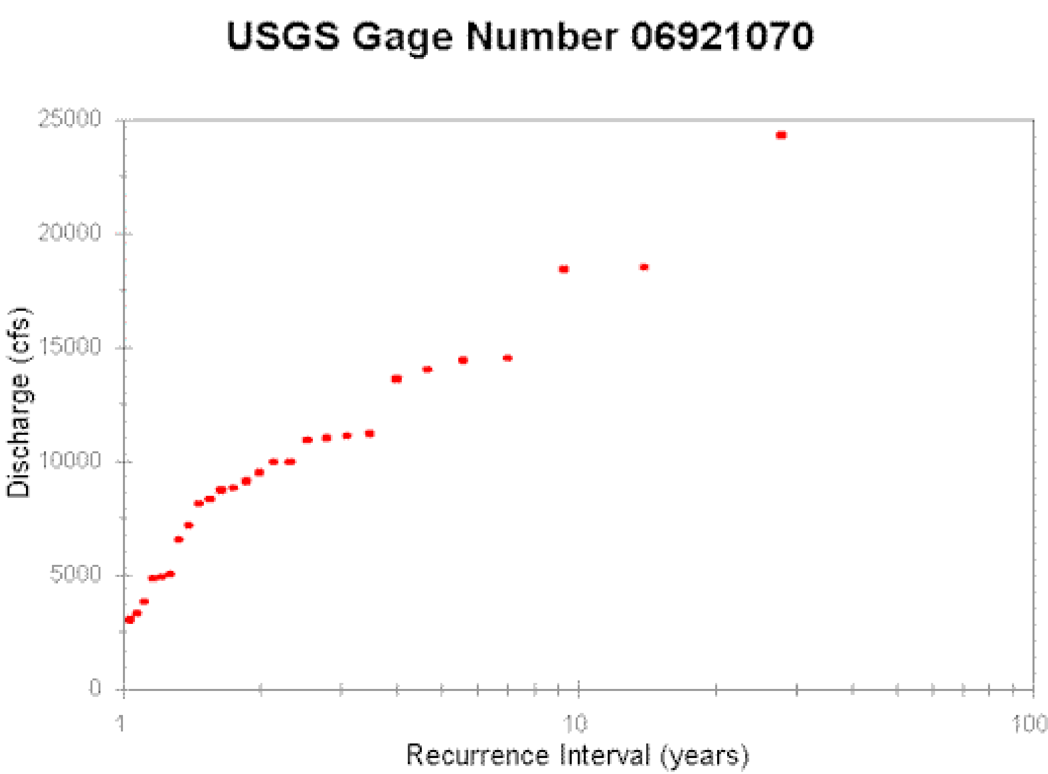
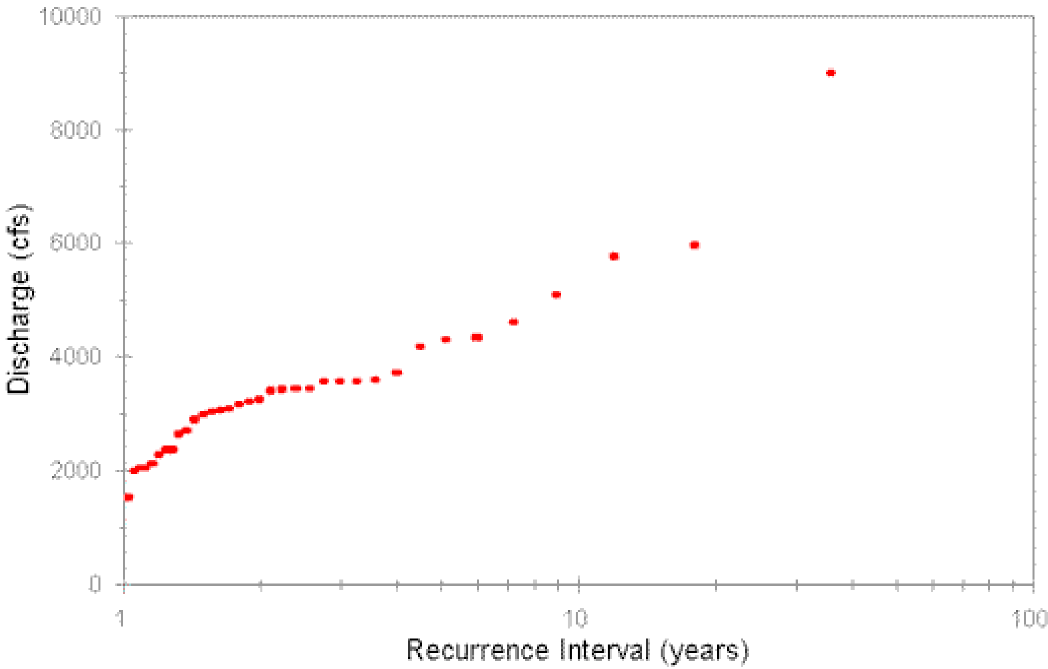


Figure HY02. Annual recurrence intervals for three active USGS gage stations in the Pomme de Terre River watershed.

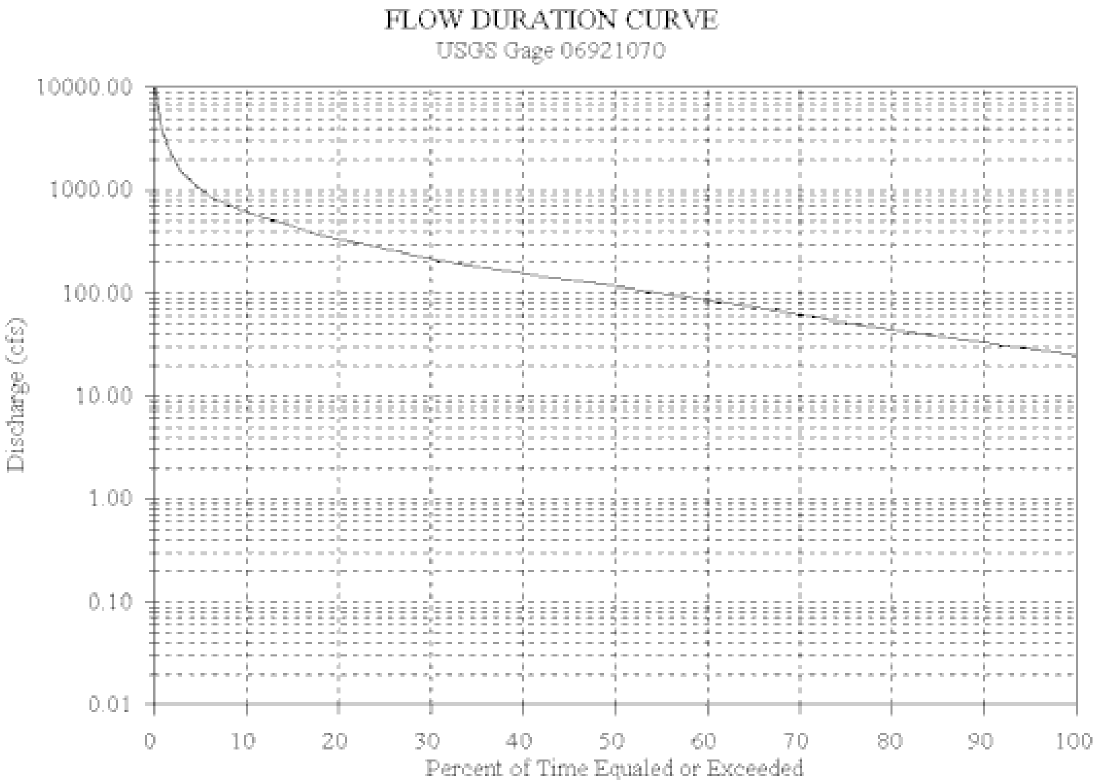


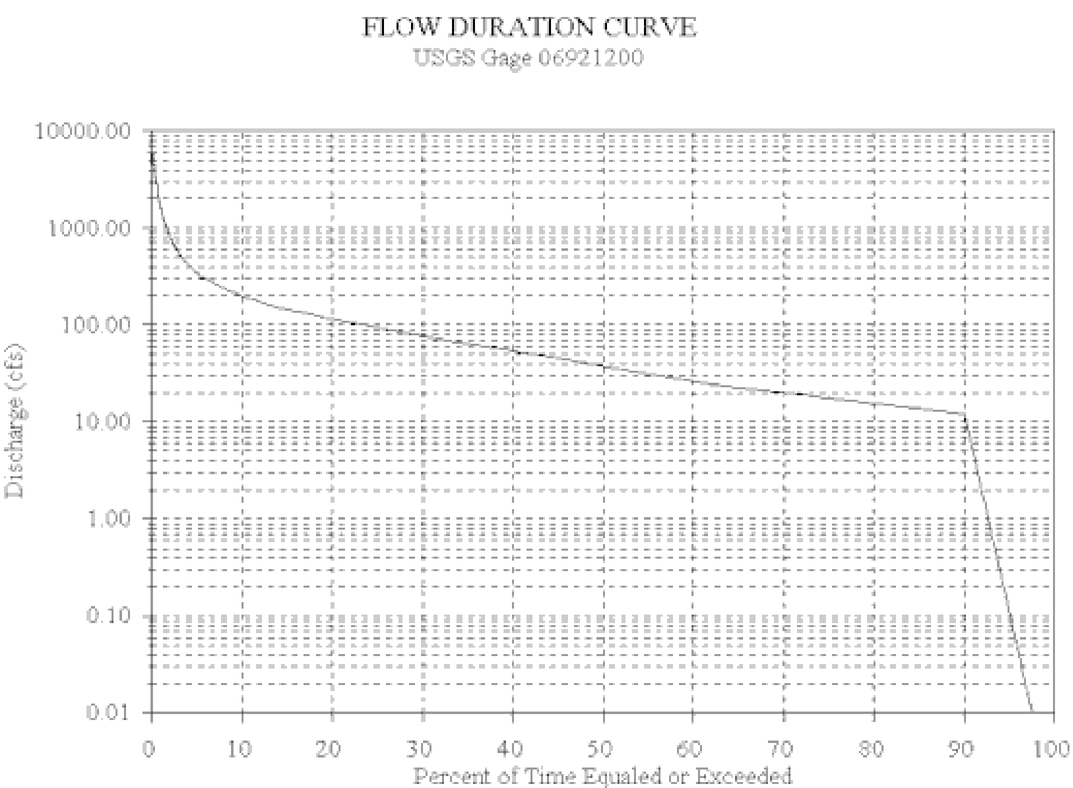


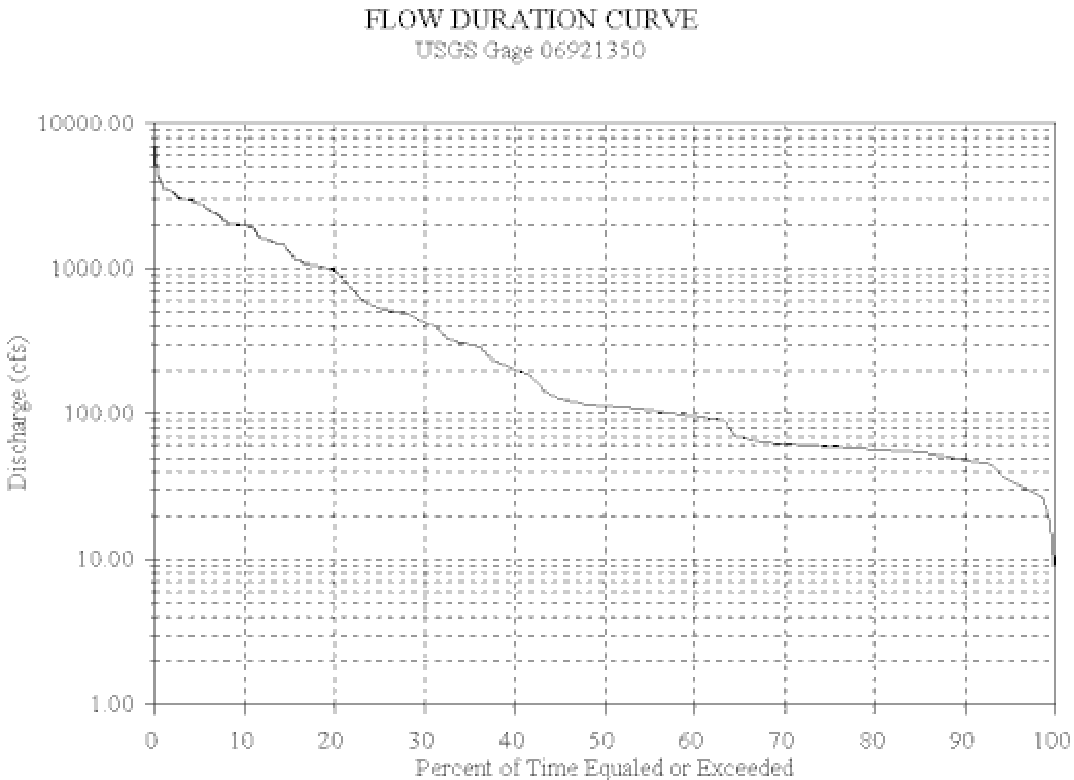
USGS Gage Number 06921350



Flow duration curves at three active USGS gage station locations in the Pomme de Terre River watershed.






FLOW DURATION CURVE
USGS Gage 06921350
Discharge (cfs)
10000.00
1000.00
100.00
10.00
1.00
0
10
20
30
40
50
60
70
80
90
100
Percent of Time Equaled or Exceeded

Terre Dam, as a result of reservoir construction. In its pre-impoundment state, the floodplain served as a source of nutrients, and functioned as a nursery area for young fish. Since 1966, no out of bank flows occur in this portion of the river as a result of dam construction and operation, separating this stretch of the Pomme de Terre River from its floodplain. Pomme de Terre Lake may also be robbing this stretch Pomme de Terre River of nutrient input from the upper watershed. The watershed above the dam once served as the major source of nutrient input, but the nutrients now become trapped in PDT Lake. Hermitage WWTF now supplies this stretch of River with some nutrients, but no studies have been done to compare the current nutrient level with that of the pre-impoundment River.

Sediment deprivation is caused when sediment that once traveled into this stretch of River is now trapped in Pomme de Terre Lake. Sediment that is removed, from the section of River below the Dam, is no longer replaced by upstream sediment. This may be reducing substrate diversity by removing smaller sediment particles more readily than larger particles without replacing them. In their natural state, river channels function as conveyor belts. Sediment that is removed from one section of river is replaced by sediment from upstream. Water with less suspended sediment and bedload, water released from the dam, has more erosive power, and more ability to transport suspended sediment and bedload. The end result in many cases is the removal of substrate particles without replacement from upstream (Kondolf 1997). This in effect reduces the substrate diversity (fewer sizes), which in turn has the potential to reduce the diversity of aquatic life.

Accelerated erosion is problematic in the section of Pomme de Terre River below Pomme de Terre Dam (Dent, R., MDC, pers. comm.). Dam construction and operation have contributed to these problems. Pre-impoundment water level changes were not as dramatic as post-impoundment changes, in this stretch of River. River levels rose and receded relatively slowly, allowing banks to dry out slowly and remain stable. Out of bank flows occurred, allowing the floodplain to absorb much of the energy of flood waters and relieve pressure on stream banks. Post-impoundment river levels can change drastically, in a short time, and are regulated to prevent out of bank flows. Water levels rise and fall quickly. As this occurs the banks do not have time to dry out, and saturated banks, without the support of the water column, are more susceptible to collapse. "Hungry water" exiting Pomme de Terre Dam may also be responsible for increased erosion and bank failure. The term "hungry water" refers to water that is relatively sediment free, with more erosive power. Any sediment carried into the streams above the dam has been deposited in Pomme de Terre Lake. Additionally, extended periods of bankfull flows occur. Extended bank full flows, of relatively sediment free water, are very erosive.

Logjams have been a problem in the section of Pomme de Terre River between PDT Dam and Truman Lake (Dent, R., MDC, pers. comm.). Post-impoundment conditions increase erosion and bank failure, allowing more trees to fall into the river, than might occur naturally. Historically, out of bank flows would periodically remove debris that entered the river and deposit them on the floodplain.

Release water is drawn from the hypolimnetic (lower) portion of Pomme de Terre Lake. At times release water can become low in dissolved oxygen. Artificially low levels of dissolved oxygen negatively impact fish and invertebrates in the section of river directly below the dam.

Key factors influencing the distribution and abundance of stream fishes include: water quality, temperature, physical habitat structure, flow regime, energy sources (food), and biotic interactions (Karr and Dudley 1981). This probably holds true for other aquatic biota as well. Each of these factors in Pomme de Terre River have been altered to one extent or another. This has likely resulted in a biotic

Table HY01. Active and discontinued USGS gaging stations in the Pomme de Terre River watershed.

Gage #	Gage Name	Period of Record	
	ACTIVE STATIONS		
Gage #	**Gage Name**	**Period of Record**	
		From	**To**
06921070	**PDT River near Polk**	**1968**	**Present**
06921200	**Lindley Creek near Polk**	**1957**	**Present**
06921350	**PDT River near Hermitage**	**1960**	**Present**
	DISCONTINUED STATIONS		
Gage #	**Gage Name**	**Period of Record**	
		From	**To**
06921000	**PDT River near Bolivar**	**1950**	**1969**
0692150	**PDT River near Hermitage**	**1921**	**1965**

Table HY02. Mean monthly and annual discharges, and low flow statistics at active USGS gage stations in the Pomme de Terre River watershed.

Gage Number	Mean Monthly Discharge (ft^3/s)											
	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
06921070[1]	285	334	551	551	385	252	79	42	172	155	390	367
06921200[1]	100	126	193	186	160	83	35	15	59	80	112	127
06921350[2]	599	636	862	926	820	626	388	114	143	347	631	748

Gage Number	Mean Annual Discharge (ft^3/s)[1]	7-day Q^2 (ft^3/s)	7-day Q^{10} (ft^3/s)
06921070[1]	296	3.0[2]	0.5[2]
06921200[1]	106	0.0[3]	0.0[3]
06921350[1]	569		

[1]For the period of record for gages 06921070 and 06921200.
For water years 1964 through 1995 for gages 06921350.
[2]For water years 1968 through 1991.
[3]For water years 1957 through 1991.

Table HY03. Dams located within the Pomme de Terre River watershed (EPA 1997).

Dam Name	Normal storage (acres)	Impoundment Name
Jensen Lake Dam	33	
Gordan Lake Dam	35	
Hawk Lake Dam	40	
Hilliard Estates Lake Dam	47	Hilliard Estates Lake
Salisbury Lake Dam	48	Salisbury Lake
Mueller Lake Dam	49	Mueller Lake
Hardeke Lake Dam	81	Hardeke Lake
McNerney Lake Dam	104	Chester Jenkins Lake
Woods Lake Dam	186	
Pomme de Terre Dam	7,820	Pomme de Terre Lake

Table HY04. Modifications to the Pomme de Terre River resulting from the construction of Pomme de Terre and Harry S. Truman lakes.

Stream segment	PDT-Osage River confluence to top of Truman Lake normal pool (706 ft.)
Modification	Inundation by Harry S. Truman Lake, loss of riverine habitat
Distance	20 miles of the original Pomme de Terre River channel
Stream segment	Top of Harry S. Truman Lake normal pool to Pomme de Terre Dam
Modification:	Pomme de Terre Dam release, alteration of hydrologic regime
Distance	21.6 miles of the original Pomme de Terre River channel
Stream segment	Pomme de Terre Dam to PDT Lake normal flood pool level (839 feet)
Modification:	Inundation by Pomme de Terre Lake, loss of riverine habitat
Distance:	18.3 miles of original Pomme de Terre River channel
Stream segment	Top of PDT Lake normal pool level to maximum pool level (874ft)
Modification:	Inundation by Pomme de Terre Lake during flood events
Distance:	10 miles

community that looks very different now than it did before the construction of the two reservoirs. Also, Ryck (1973) reported, "Low temperature discharges through Pomme de Terre Dam have a detrimental effect on the fishery in the tailwaters."

Annual "Water Level Management Recommendations" have been developed by MDC for input to the USACE on Pomme de Terre Lake level management and dam releases since 1985. Table HY05 lists the 1998-99 recommendations and expected benefits. The management objectives of the recommendations are to; 1) improve spawning habitat in the Pomme de Terre River for walleye and white bass from March 10-April 30; 2) improve walleye and white bass fishing during the spring spawning run below Pomme de Terre Dam; 3) increase recreational opportunities for fishing and canoeing in the Pomme de Terre River during summer; 4) improve spawning habitat for prey fishes such as gizzard shad and sport fishes in Pomme de Terre Lake from April 1-June 15; and 5) reduce bank erosion along the Pomme de Terre River during evacuation of flood waters beyond lake elevation 841 ft. msl. The plan has been generally followed, except where exceptionally high inflows and/or high water in downstream reservoirs necessitated deviations.

Desired recreational benefits have been achieved. Flooding of vegetation in PDT Lake during the spawning and nursery period improves reproduction and survival of largemouth bass and gizzard shad. Large year classes of both gizzard shad and largemouth bass have been common in PDT Lake since the plan was initiated. Similar water level manipulations have produced equivalent results in other southern and Midwestern reservoirs (Keith 1975, Groen et al. 1978, Miranda et al. 1984, Fisher and Zale 1991). Spawning conditions for walleye and white bass and stream flows in the river below Pomme de Terre dam have also improved.

Every five years the USACE dewaters the Pomme de Terre River, directly below Pomme de Terre Dam, to inspect the dam structure. The project was last completed in October 1996 and should be repeated in the fall of 2001. High flows (3,000-6,000 cfs) were released from the dam for 10 minutes before a large blocking net was placed across the river. The high flows served to flush fish out of the area directly below the dam. The block net was placed to prevent fish from returning to the area. Flow from the dam was then ceased and a coffer dam built to keep water out of the area. Water was slowly pumped down until the area became dry and the dam structure was examined. MDC personnel assisted in the project by removing trapped fish. Striped bass, hybrid striped bass, white bass, and walleye were transported back to Truman Lake. Black bass, sunfish, and all other fish were transported to Pomme de Terre Lake. Some fish have died due to overcrowding and low dissolved oxygen during dewatering and fish removal (Meade, R., MDC memo, Oct., 8, 1996).

Table HY05. Missouri Department of Conservation 1998-99 Pomme de Terre Lake water level management recommendations.

FALL-WINTER (November-February)	
Recommendations	**Flood releases should not exceed 1,000 cubic feet per second (cfs) and ramping should be utilized so that releases do not exceed a 500 cfs change within a 24-hour period. Evacuation of flood flow releases sooner than anticipated may be necessary to avoid or reduce excessive rises in lake level. Half to three-quarter bank full flows (>2,000 cfs) should be minimized throughout the year.**
Benefits	**Avoiding artificially high flows will prevent excessive bank scour downstream of the dam in the Pomme de Terre River.**
SPRING (March-May)	
Recommendations	**Maintain lake water levels at 2 f.t above normal pool (841 feet mean sea level (msl)). When lake water temperatures reach 45º Fahrenheit, increase outflow to 100 cfs. Spring discharges should be continuous and not exceed 300 cfs. Surface water releases should be utilized as much as possible.**
Benefits	**Elevated water levels will enhance spawning habitat for reservoir fishes from March through May. Limited, continuous releases will improve spawning habitat for walleye and white bass below the dam. Surface water release will maintain favorable water temperatures for river spawning fish.**
SUMMER (June-October)	
Recommendations	**Maintain the lake level at 841 msl until June 15. Beginning June 15, lake may be drawn down to 829 msl if needed for dock maintenance. Discharges above 500 cfs should be avoided. Outflow of at least 100 cfs should be maintained as long as possible through the summer. Lake water may need to be stored following periods of summer inflow, to provide sufficient water for continuous summer releases.**
Benefits	**Maintaining elevated water levels through June will provide sportfish habitat and fishing opportunities in the lake. Drawdown beginning June 15 will allow shoreline vegetation to recover from flooding. Discharges greater than 500 cfs should be avoided to prevent bank erosion below the dam. Maintaining outflows throughout the summer will provide favorable sportfish habitat and fishing and canoeing opportunities below the dam.**